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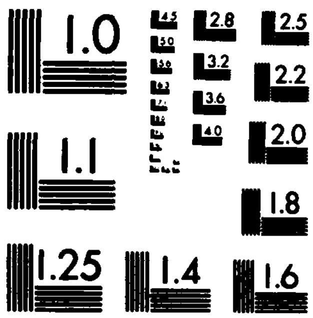

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An Assessment of the AN/GMQ-13 Cloud Height Set Capability to Meet AWS Requirements

FREDERICK J. BROUSAIDES

12 December 1982

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The capability and performance of the AN/GMQ-13 Cloud Height Set, commonly referred to as the Rotating Beam Ceilometer (RBC), was reviewed. Included in the study is an assessment of its ability to meet specific requirements for automating the measurement of cloud field properties, that is, layering and cloud cover, through the application of the heirarchical clustering technique. It is concluded that a single RBC system cannot meet current stated requirements for cloud height measurement. An RBC with a 1600 ft over

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20. ABSTRACT (Contd.)

baseline can meet the high altitude requirement but has difficulty with low ceilings that are also associated with conditions of restricted visibility. An RBC with a 400-ft baseline does well at low altitudes but is totally inadequate at high altitudes. An obvious compromise would be the deployment of two RBCs, or one projector and two receivers. The heirarchical clustering technique for the determination of cloud field properties was previously demonstrated in AFGL and AWS field tests. The resolution and accuracy to be obtained is a function of the number of ceilometers available, their orientation, and time averaging considerations.

Contents

Illustrations

Tables

An Assessment of the AN/GMQ-13 Cloud Height Set Capability to Meet AWS Requirements

1. INTRODUCTION

Under the Weather Systems (Advanced Development) Program the requirement exists for improved sensing techniques for clouds and present weather. Until such time that emerging technologies such as lidar and microwave systems are proven and operational, the AN/GMQ-13 Cloud Height Set will remain the field instrument of choice for fixed and bare-based airfield operations. This report summarizes the capabilities of this instrument as an interim device to meet current stated AWS requirements. Included in the study is an assessment of AN/GMQ-13 capability to meet specific requirements for automating the measurement of cloud field properties, that is, layering and cloud cover, through the application of the heirarchical clustering technique. Field tests performed by the National Weather Service and the Air Force Geophysics Laboratory were the basis for the evaluation.

(Received for publication 2 December 1982)

2. AN/GMQ-13 CLOUD HEIGHT SET PERFORMANCE

The AN/GMQ-13, Cloud Height Set, more commonly referred to as the Rotating Beam Ceilometer, or RBC, is the primary AWS ceiling detector. This instrument has been in operation for three decades and is the standard against which alternative techniques are often compared. This is not to imply that the RBC necessarily provides a "true" estimate of cloud height. Different sensors may yield different cloud height estimates depending upon the specific technique employed and the assumptions made in signal processing. The value of the RBC as a comparison standard is due to its widespread application and an extensive field history of performance. Because of the importance of this instrument, a brief review of the principles of operation as well as its ability to meet future operational requirements will be made.

The RBC is composed of three major components, namely, projector, detector, and indicator. The measurement technique involves triangulation. The projector transmits beams of light that rotate in a plane normal to the ground. Light backscattered from a cloud or other aerosols reaches a remote and vertically pointing detector that is in the plane of the light beam. Knowing the baseline distance and the projector angle, a calculation of cloud base height can be made. A system block diagram is shown in Figure 1.

The projector is provided with two identical back-to-back optical systems. The lamps in these two systems are located at the focus of parabolic reflectors that have a diameter of 24 in. In optimum condition, the optical systems produce 3,000,000 candela. A shutter mechanism modulates the light at 120 Hz (line frequency dependent) to permit identification of cloud scattered light by the detector. An infrared filter incorporated into the projector housing prevents most of the visible lamp light from being transmitted.

The optical assembly is rotary mount driven at a rate of 5 rpm. Thus, a beam of light sweeps the sky through an arc of 0 to 90^{o}, ten times a minute. The dual lamp system provides a backup capability in the event of a lamp failure and also will give an indication of system malfunction if disparate results are noticed between successive sweeps. The system is often operated with only one lamp, however, providing a measurement every 12 sec.

Light reflected from a cloud or obstruction, and in the detector field-of-view, is collected by a reflector similar to one used in the projector and focused upon a photo-conductive infrared detector. Ninety percent of the visible light is screened out by an infrared filter used as a cell cover glass. The detector housing is provided with space heater elements, blower, and thermostat to prevent the accumulation of ice or snow during freezing weather.

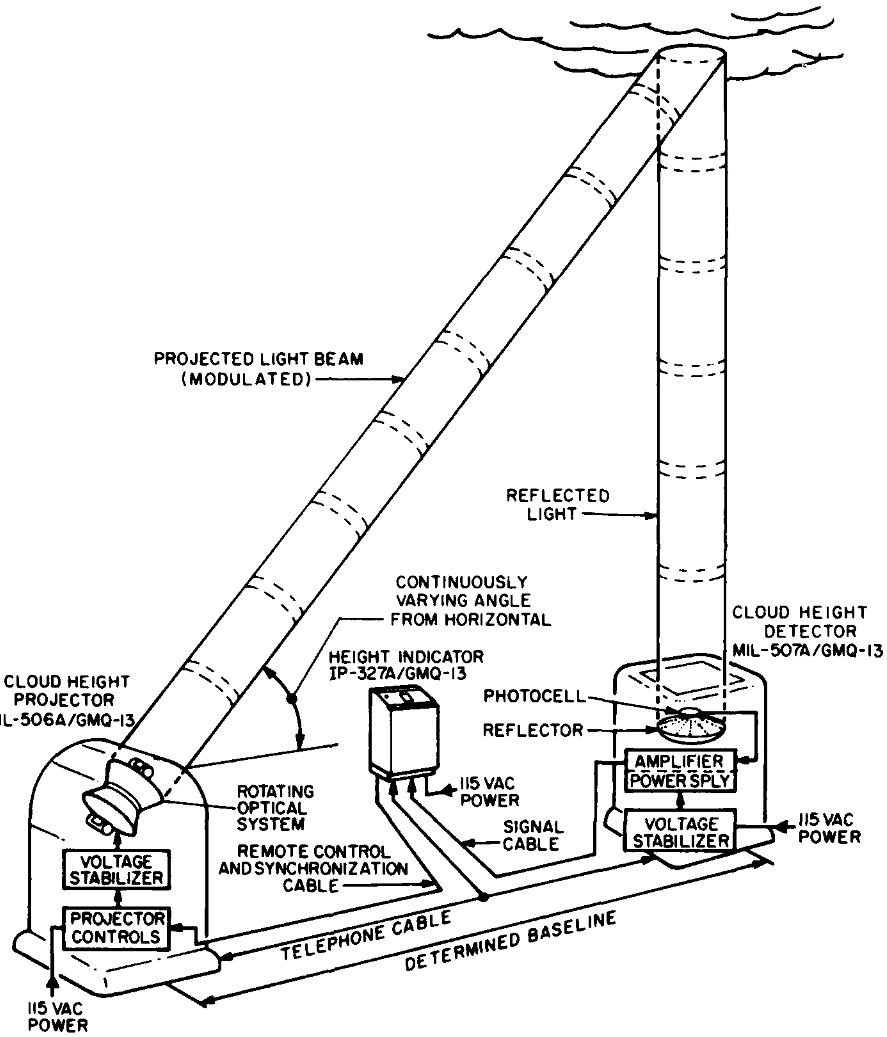

Figure 1. AN/GMQ-13, Block Diagram

Signals from the detector are fed into a cathode ray tube (CRT) of the indicator and/or to a recorder. The sweep of the CRT is synchronized with the projection of the light beam. As the signal progresses up the display tube, the beam widens as it receives backscattered light from a cloud. The widest portion of the signal is usually attributed to the location of the cloud base.

The RBC is a fixed location system requiring concrete mounting pads for both the projector and receiver. The system is cumbersome and weighs in excess of 2,000 lb. Considerable unobstructed real estate is also required. These requirements often deter its utilization.

The cloud height set is, generally, operated at relatively short baseline distances of 400 to 900 ft. This restricts measurements of 10 percent accuracy, or less, to below 5,000 ft, which is in the range of principal interest for airfield traffic control. Since it is difficult to align the system more accurately then 1°, this value is often referred as the minimum angular uncertainty in the measurement. This value is in keeping with field tests where one projector and two collocated receivers are used.[1] In the NWS study, RBC measurement precision was estimated as $\pm 3/4^{\circ}$. The absolute height error in the measurement increases with increasing projector elevation angle. However, the relative error is given by the expression:

$$\frac{dh}{h} = 2 \operatorname{cosec} 2\theta \cdot d\theta \ .$$

Figure 2 shows the relative error as a function of projector angle. It may be seen that the error is at a minimum at 45°, a measurement at which the height is equal to the baseline. Table 1 gives the range of RBC measurement (ft) as a function of lowest acceptable accuracy for various baseline distances.

Cloud height uncertainties and estimated resolutions for various altitudes and baselines are provided in Table 2, along with AWS requirements (Appendix A Table 2). The accuracies are based upon an assumed 1° tracking error. Resolution estimates are based upon the following reasoning: The RBC rotates at 5 rpm and sweeps an arc of $30^{\circ}\ \mathrm{sec}^{-1}$. As the shutter is modulating the beam at 120 Hz, the light off-time, or maximum resolution, is equivalent to $\frac{30}{120\ \mathrm{Hz}} = 0.25^{\circ}$. It should be stressed that 0.25° represents a maximum instantaneous uncertainty. When data is averaged for 1 or 2 min, the mean

1. (1971) Evaluation of Common Ceilometer Technology, Staff, Observation Techniques Development & Test Branch, NOAA NWS T&EL-13.

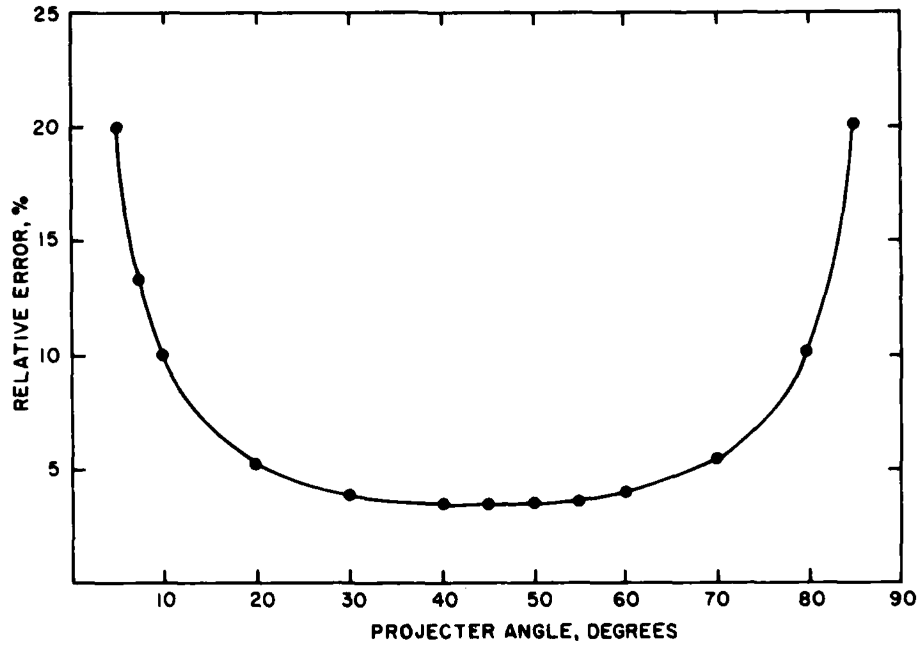

Figure 2. Relative Error as Function of Projector Angle

Table 1. RBC Accuracy and Range of Measurement

Accuracy	Baseline, Ft 1000	800	600	400
10%	180- 5, 549	144-4, 440	108-3, 330	72-2, 220
20%	88-11, 371	70-9, 097	53-6, 823	35-4, 548

resolution will be more nearly one half the maximum value. The resolution values in Table 2 are the mean resolution uncertainties. Thus, for all intents and purposes, the RBC will meet all AWS stated future resolution requirements.

It would appear from the RBC uncertainty estimates shown in Table 2 that the 1600 ft baseline is the best compromise between performance at all altitudes and AWS requirements. However, RBC performance is degraded during heavy precipitation or fog. Since low clouds are often associated with conditions of

Table 2. RBC Accuracy and Resolution

Range, Ft	AWS Requirements Accuracy	AWS Requirements Resolution	Estimated Accuracy and Resolution ( ) Baseline, Ft 400	800	1600
100	100	100	7 (1)	15 (2)	28 (4)
500	100	100	18 (2)	19 (2)	31 (4)
1000	100	100	51 (6)	36 (5)	39 (5)
2000	100	100	182 (23)	101 (13)	72 (9)
3000	100	100	400 (50)	210 (26)	126 (16)
4000	400	100	705 (88)	363 (43)	202 (25)
5000	500	100	1098 (137)	559 (70)	301 (38)
6000	600	500	1578 (197)	799 (100)	421 (53)
7000	700	500	2145 (268)	1083 (135)	562 (70)
8000	800	500	2860 (350)	1410 (176)	726 (91)
9000	900	500	3541 (443)	1781 (223)	911 (114)
10, 000	1000	500	4370 (546)	2196 (274)	1119 (140)

poor visibility, RBC operation suffers from both beam attenuation and light scattering effects that broaden the signal return and make the determination of the angle of maximum return (that is, cloud base height) very difficult. Thus, when concerned with cloud height measurements at low altitudes a shorter baseline is required. RBC operation at longer baselines is dictated by the altitude at which maximum accuracy is desired.

Some knowledge of the light beam pattern at altitude and the detector's field-of-view might be useful when decisions are made concerning the optimum averaging time. From the specifications for detector and filament dimension (both are 20 × 4 mm) and the reflector focal length (10 in.) it can be shown that the receiver and projector cone angles are $4.5^{\circ} \times 1.8^{\circ}$.[2] Table 3 shows the dimensions of the cross sections of both cones as a function of altitude for baseline distances of 400 to 800 ft. It should be noted that though the tabular values for the projector cone cross-sections indicate pattern rectangularity, it is more

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2. (1959) MIL-C-4688A (USAF).

precisely trapezoidal. It may be seen that the receiver field-of-view and projector beam patterns are well matched above 2000 ft. Strong signal strengths below 2000 ft are more than adequate to compensate for pattern mismatch.

Table 3. Cross-Section Dimensions of Receiver and Projector Cones

Altitude, Ft	Receiver, Ft^2	Projector, Ft^2 Baseline 800 Ft	400 Ft
10,000	786 × 314	788 × 316	786 × 314
5,000	393 × 157	398 × 161	394 × 159
3,000	236 × 94	244 × 101	238 × 96
2,000	157 × 63	169 × 73	160 × 65
1,000	39 × 31	101 × 52	85 × 36
200	16 × 6	65 × 107	35 × 31

The rather large areal coverage of the RBC, compared with narrower field-of-view instruments, such as laser ceilometers, may be considered advantageous in that an individual measurement is representative of an appreciable section of the cloud base. It may be noted, for example, that at 2000 ft with a cloud motion of 10 mph, it would take from 6 to 16 seconds for the cloud section being monitored to completely absent the field of view.

From a consideration of RBC capability and performance, it is evident that AWS accuracy requirements for priority cloud heights cannot be achieved. An RBC with a 1600 ft-baseline can meet high altitude cloud detection requirements reasonably well but has difficulty with low ceilings that are associated with conditions of restricted visibility. An RBC with a 400 ft-baseline does well at low altitudes but is totally inadequate at high altitudes. An obvious compromise would be the deployment of two RBCs, or one projector and two receivers. This latter procedure is, in fact, operational at the Dulles Airport, Washington, D.C. Though an immediate solution to AWS requirements, this is expensive and in many locations not capable of implementation. A recapitulation of capability and requirements is given in Table 4.

Table 4. AN/GMQ-13 Capability to Meet AWS Cloud Height and Ceiling Requirements

Attribute	Requirement	Capability
Range (Ft)	10, 000	Achievable
Resolution (Ft)	100 (0-5k) 500 (5-10k) 1000 (above 10k)	Marginal (Baseline dependent) Marginal (Baseline dependent) Marginal (Baseline dependent)
Accuracy (Ft)	±100 or 10% ±100 (0-3k) ±10% above	Marginal except for lowest 2000 ft where accuracy is acceptable
Layers (Ft)	All layers to 10, 000	Achievable
Update	1 minute	Achievable with automation

As previously mentioned, resolution requirements for a ceilometer are essentially satisfied with the RBC. Also, the requirement for multilayer detection poses no problem. Recent efforts have led to the development of an improved display for the RBC as well as for digital signal processing.[3] This latter system is a major advance in the automation of the AN/GMQ-13 and provides the user with several selectable modes of operation. In the first mode, the latest RBC scan is displayed. In the second mode, five successive scans are used to produce an objectively determined cloud base height. A third manual-interactive mode permits the operator to hold a scan and, with a cursor, to extract additional height information from any portion of the signal display.

3. AUTOMATION OF THE AN/GMQ-13

3.1 Techniques

Duda, et al[4, 5] considered various computer model simulations for the automation of vertically pointing ceilometers to provide information on cloud field statistics, namely, cloud heights and layer amounts. The validity of some of these techniques were essentially confirmed in separate field tests performed by both the NWS and AFGL utilizing the standard AN/GMQ-13, RBC. The method is applicable to other present and emerging remote systems, for example, laser

References 3 to 5 will not be listed here. See References, page 21.

and microwave, which can provide information on cloud presence at one or more altitudes in the vertical.

A given specified accuracy in the determination of cloud base height or amount determines the requisite spatial and temporal sampling requirements. It is evident that, an infinite number of instruments in the area of interest, sampling continuously, can specify cloud condition exactly. In the practical world, the placement of a limited number of ceilometers becomes a factor. In the absence of a preferred cloud movement direction, this placement should be such as to maximize the number of independent measurements sampled. The optimum averaging time must take into account the systematic fluctuations in the cloud field, yet be long enough to reduce the expected mean squared error estimate in the cloud amount to the desired extent. Figure 3, from Duda et al,[4] shows the expected error in cloud amount for one and four instruments, with and without time averaging, as a function of $A^{1/2}/\ell m$, where A is the area sampled and ℓm is the mean cloud length. It was shown that with time averaging, the root mean square (rms) error will always be less than 0.17 when one ceilometer is used and less than 0.085 when four ceilometers are employed. Figure 4 (Duda) et al[4] can be used to determine the statistics associated with a given rms error in cloud amount estimation. Thus, for the four instrument case given earlier (σ = 0.085), if we desire the estimate of cover to be within 0.1 of the true value, we will be correct 78 percent of the time. Figure 5 is also useful in determining the requisite number of instruments required for a given rms error estimate. It should be kept in mind that the magnitude of these errors are not too dissimilar to those reported by Galligan[6] for human observers. When the cloud amount was near five tenths, σ ranged between 0.107 and 0.123.

In the heirarchical clustering technique recommended by Duda et al,[4] the data from each ceilometer is clustered independently from a running file of computer maintained cloud heights. A typical file contains 30 min of data. To be more responsive to changes in cloud condition, the more recent data can be given increased weight.

The measurements are rank-ordered according to increasing height ($h_1 < h_2 \ldots < h_n$) in a set of n clusters. The number of clusters are successively reduced by combining closest pairs until all data are reduced to a specified minimum number of clusters. After clustering has been completed, clusters are further combined if they are less than a given maximum separation distance.

6. Galligan, A.M. (1953) Variability in Subjective Cloud Observations (I), Air Force Surveys in Geophysics, No. 33 AFCRC-TR-53-10, AD 11911, Cambridge, Mass.

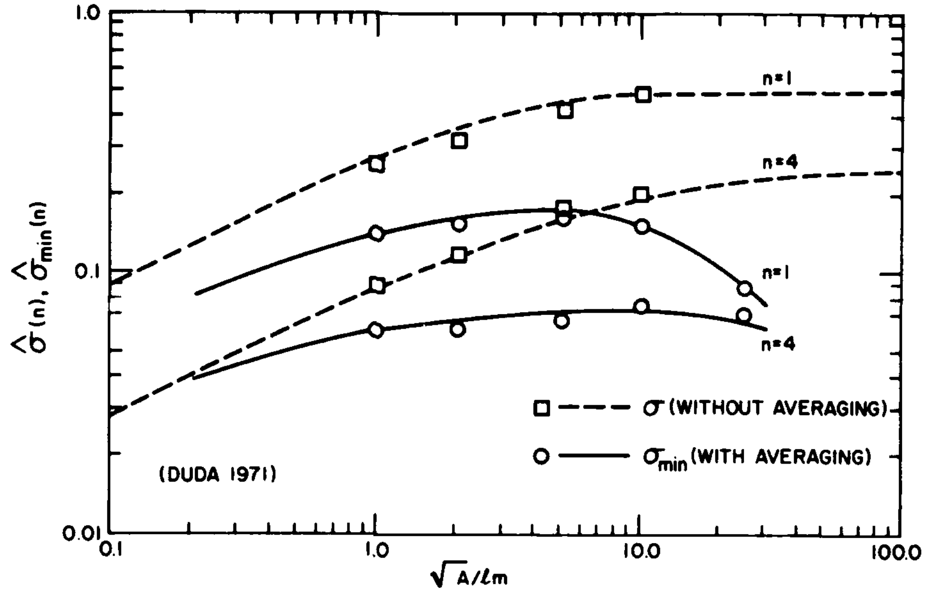

Figure 3. Reduction of Root Mean Square Error by Optimum Averaging

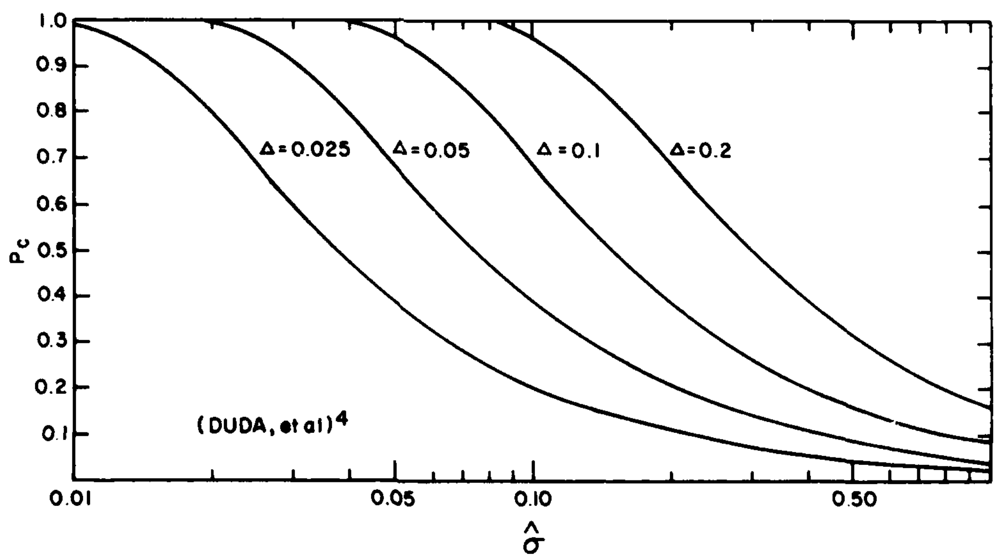

Figure 4. Probability That the Estimated Cloud Amount is Within ±Δ of the True Cloud Amount

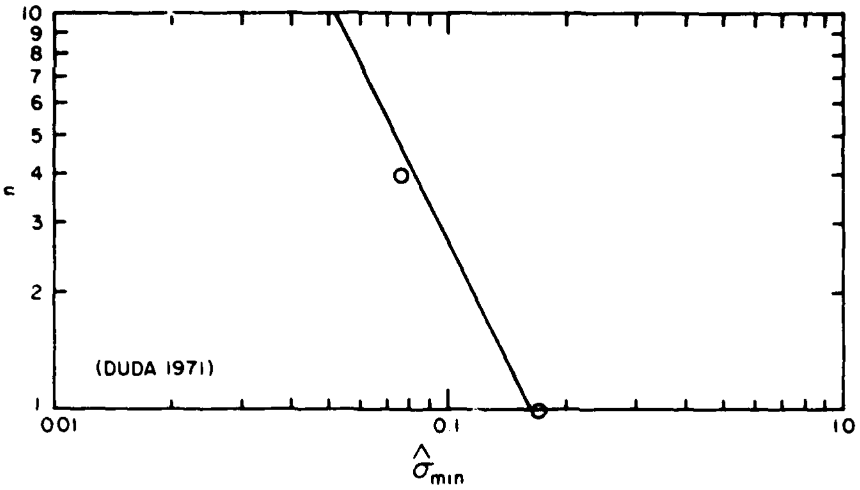

Figure 5. Required Number of Instruments Using Optimum Averaging

This separation distance also varies with altitude. If more than one ceilometer is used, this consolidation procedure is eventually extended to all data.

For the lowest cloud layer, a cloud cover factor is calculated from the ratio of the number of cloud heights and the total number of possible hits. Total sky cover for multiple layers is calculated according to *FMH-1 summation rules.*

3.2 AV-AWOS Field Test Results

The AV-AWOS (Aviation Automated Weather Observation System) was designed for the total automation of aviation surface weather observation.[7] Field test results in 1978 had the objective of comparing routine ground observations of weather with automated observations employing both cloud and visibility algorithms. For the cloud observations, three RBCs were placed in a triangular pattern. Tests were conducted at two locations, namely, Dulles International Airport, Va. (IAD), and Patrick Henry International Airport, Va., (PHF). Ceilometer separation at Dulles was 3.3, 5.4, and 6.9 miles, respectively. The design length of each leg of the ceilometer triangle at PHF was said to be about 7 miles.

Computer-generated observations of cloud cover for the three ceilometer AV-AWOS networks were compared with both human observations as well as independently processed ceilometer measurements. Comparisons were also made between independently processed, physically separated RBCs.

7. (1979) Aviation Automated Weather Observation System (AV-AWOS). NWS Report No. FAA-RD-7963.

When computer-generated cloud layer observations from either the three RBC networks or independent ceilometers were compared with human observations, the agreement was considered good with indications that clustered data derived from various sources were consistent.

Results of cloud layer comparisons for various methods are shown in Table 5. In the AV-AWOS analysis, "agreement to ±1 layer, for example, means that a human report of 1 layer would be compared with the number of observations in the 0, 1, and 2 layer categories of the appropriate paired sensors."[7]

Table 5. Number of Cloud Layers: Comparison of Methods

Methods	% Agreement ±1 Layer
AV-AWOS/IAD observer	74%
AV-AWOS/PHF observer	87%
Two separated RBCs/IAD	89%
Two separated RBCs/PHF	92%
AV-AWOS/separated RBC/PHF	85%

Table 6 summarizes the ceiling height comparisons. It was believed that the decreasing agreement with increasing altitude reflects the basic RBC system characteristics, where the ability to resolve heights decreases with increasing projector angle.

3.3 AFGL Automated Cloud Observation System (ACOS) Field Tests

The study at AFGL relied upon the techniques developed by Duda et al and put into practice by the National Weather Service in the AV-AWOS tests.[8] One of the main differences between AFGL and the AV-AWOS tests was in the size of the RBC network. In order to more clearly simulate the size constraints of the typical airfield environment, RBCs at AFGL's Weather Test Facility (WTF), Otis AFB, Mass., were in a triangular pattern separated by about 1 and 2 miles. Human observations were taken by FAA personnel located approximately 1 mile from the test site.

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8. Geisler, E. B., and Chisholm, D. A. (1980) An Automatic Cloud Observation System (ACOS), AFGL-TR-81-0002, AD A100266.

Table 6. Ceiling Height Values: Comparison of Methods

Methods	% Agreement to ±200 ft
Ceiling: 100 to 1000 ft	
AV-AWOS/IAD observer	96%
AV-AWOS/PHF observer	75%
Two separated RBCs/IAD	82%
Two separated RBCs/PHF	85%
AV-AWOS/separated RBC/PHF	92%
Ceiling: 1100 to 3000 ft	
Methods	% Agreement to ±400 Ft
AV-AWOS/IAD observer	63%
AV-AWOS/PHF observer	53%
Two separated RBCs/IAD	82%
Two separated RBCs/PHF	75%
AV-AWOS/separated RBC/PHF	74%

Cloud height data were taken during a 7 month period in 1980 in which 41 episodes were selected for analysis. Episodes were chosen based on the following criteria:

1. had a length of at least 3 hr;
2. occurred during a period in which at least one RBC was operating; and
3. in which scattered, or more, clouds were reported below 6000 ft by the FAA observers.

Various methods were employed in data analysis. These included the number of ceilometers used, the number of lamps per ceilometer, the use of primary and/or secondary peaks, etc.

Typical joint accuracies of ceiling reports from human observers and the automated RBC system are shown in Table 7. Only the results from RBC data employing one lamp per ceilometer and utilizing the primary signal maximum are shown. If only ceilings below 3000 ft are considered, these percentages increase by two or three points.

A comparison of the relative frequency distributions of low cloud amounts found using the automated RBC system and the FAA observer indicates that the automated technique underspecifies cloud amounts, whether or not 1, 2, or 3 RBCs are used. With one RBC this underestimation was 10 percent. That is,

Table 7. Joint Occurrence of Ceiling Reports

1 - RBCs	2 - RBCs	3 - RBCs
84.2%	86.3%	88.6%

human observers found ceiling conditions 89 percent as compared to 79 percent for the RBC system. Overall conclusions from ACOS field tests include the following:

1. verification of the heirarchical clustering technique when applied to an RBC network in the immediate vicinity of an airfield;
2. high correspondence of cloud field statistics between automated and human observers;
3. general adequacy of one RBC versus and RBC network; and
4. equivalence of reduction techniques using either peak maximum, multiple returns, or 1-min objectively determined cloud base height data sets.

3.4 Conclusions

It is apparent from the field tests conducted by the NWS and AFGL that the heirarchical clustering technique proposed by Duda et al, is a feasible method for the automation of vertically pointing ceilometers. The resolution and accuracy to be obtained by the technique to provide information on cloud field properties will be a function of the number of ceilometers available, their orientation, and time averaging considerations.

The utility of the AN/GMQ-13 for use in an automated system has been amply demonstrated. This capability has been furthered, in no small part, by the development of a digital processing system and an improved display. Table 8 gives a synopsis of AN/GMQ-13 cloud field requirements.

Table 8. AWS Cloud Field Requirements and the AN/GMQ-13

Attribute	Requirement	Capability
Cloud Amount Layers	*Amount each layer* Summation Total sky cover	*Achievable* Achievable Achievable
Resolution	Tenths or eighths	Achievable
Accuracy	Unstated; assume ± one-eighth	Achievable with multiple ceilometers
Variable Ceiling and Cloud Amount	Below 3000 ft	Achievable to 2000 ft

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1. (1971) Evaluation of Common Ceilometer Technology, Staff, Observation Techniques Development & Test Branch, NOAA NWS T&EL-13.
2. (1959) MIL-C-4688A (USAF).
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4. Duda, R.O., Mancusco, R.L., and Paskert, R.F. (1971) Analysis of Techniques for Describing the State of the Sky-Through Automation, Federal Aviation Administration, Report No. FAA-RD-71-52.
5. Duda, R.O., Mancuso, R.L., and Serebreny, S.M. (1973) Automatic Instrument System for Determining Cloud Amount, J. Appl. Meteorol. 12:537-542.
6. Galligan, A.M. (1953) Variability in Subjective Cloud Observations (I), Air Force Surveys in Geophysics, No. 33, AFCRC-TR-53-10, AD 11911, Cambridge, Mass.
7. (1979) Aviation Automated Weather Observation System (AV-AWOS), NWS Report No. FAA-RD-7963.
8. Geisler, E.B., and Chisholm, D.A. (1980) An Automated Cloud Observation System (ACOS), AFGL-TR-81-0002, AD A100266.

Appendix A

Sky Condition Measurement Conditions

A number of Federal agencies are concerned with the surface observation of meteorological parameters.[A1] Due to their mutual and overlapping interests, a joint working committee was formed to define desirable characteristics for an automated weather observation system capable of being employed in either attended or unattended mode. This system is called the Joint Automated Weather Observation System (JAWOS). Participating agencies include the Departments of Defense, Commerce, and Transportation. JAWOS specifications for sky parameters that have been taken from proposed requirements are shown in the sections that follow. Attributes are prioritized parenthetically on a scale of 1 to 10. A value of 10 is considered essential and a value of 1 is least important.

A1. Joint Automated Weather Observation System (JAWOS), Proposed Functional Requirements, Prepared by the Working Group on Specifications of the Panel on Automated Meteorological Observing Systems, February 1981.

A1. SKY CONDITION PARAMETERS

A1.1 Cloud Layer Height

Definition: The height of the base of any cloud layer above the surface or field elevation.

Requirements:

Attribute	AWS	NWS	FAA	JAWOS
Range (Ft)	10,000(10) 20,000(7) 40,000(5)	7,000(10) 10,000(7) 20,000(5)	4,000(10)	10,000(10) 20,000(7) 40,000(5)
Resolution (Ft)	100(0-5K) 500(5-10K) 1,000 (above 10K)	100(0-5K) 500 (above 5K)	100(0-4K)	100(0-5K) 500(5-10K) 1,000(above 10K)
Accuracy (Ft)	±100 or 10% (10) ±100(0-3K) and ±10% above (7)	±100 or 10%	±50(0-500) ±10% (500-4K)	±50(0-500) ±10% (above 500)
Layers* (Ft)	All layers to 10,000(10)	Up to 3 layers to 10,000	Up to 3 layers to 4,000	All layers to 10,000
Update	1 min	1 min	1 min	1 min

*All layers seen from point of observation with priorities noted above. A cloud layer is defined as an array of cloud elements whose bases are at approximately the same level. It may be either continuous or composed of detached elements.

A1.2 Cloud Type

Definition: A cloud form which is identified according to WMO International Cloud Atlas.

Requirements:

Attribute	AWS	NWS	FAA	JAWOS
Cb	(10)	(5)	(0)	(10)
Cb MAMMA	(10)	(5)	(0)	(10)
Towering Cu	(8)	(3)	(0)	(8)
Standing, Lentic Rotor	(10)	(3)	(0)	(10)
AC Castellanus	(8)	(3)	(0)	(8)
27 States of Sky For Cloud Code Groups	(5)	(3)	(0)	(5)
10 Basic Types for METAR	(8)	(0)	(0)	(8)

A1.3 Cloud Amount

Definition: The amount of sky cover at a given level.

Requirements:

Attribute	AWS	NWS	FAA	JAWOS
Layers				
Amount of each	(10)	(0)	(0)	(10)
Summation up to	(10)	(10)	(10)	(10)
Total sky cover	(7)	(3)	(3)	(7)
Resolution				
Tenths	(10)	(10)	(10)	(10)
Eighths	(10)	(10)	(0)	(10)
Range	Zero to 1(10)	(10)	(10)	(10)
Update Rate	1 min	1 min	1 min	1 min

A1.4 Ceiling Layer Height

Definition: The height ascribed to the base of the lowest layer of clouds reported as broken or overcast.

Requirements: Same as cloud layer height.

A1.5 Ceiling or Sky Condition at a Distance Different from that at Station

Definition: (1) This condition is reported when the bases of cloud elements contained in the ascribed ceiling layer are found to be significantly higher or lower at one or more instrumental sites in the observing network.
(2) This condition is reported when height data from a remote site show that the bases of cloud elements in a layer computed to be the ceiling layer for that specific site are significantly higher or lower than the height of the ceiling layer ascribed to the normal point of observation.

Requirements: Same as cloud layer height.

Attribute	AWS	NWS	FAA	JAWOS
Priority	(10)	(10)	(10)	(10)

A1.6 Variable Ceiling Below 3000 Ft

Definition: A situation in which a ceiling of less than 3000 ft rapidly increases and decreases by one or more reportable values while the ceiling height is being determined.

Requirements: Same as cloud layer height.

Attribute	AWS	NWS	FAA	JAWOS
Priority	(10)	(10)	(10)	(10)

A1.7 Variable Cloud Amount Below 3000 Ft

Definition: A situation where the sky condition has varied between reportable conditions (for example, SCT to BKN) during the period of observation.

Requirements: Same as cloud layer height.

Attribute	AWS	NWS	FAA	JAWOS
Priority	(10)	(10)	(10)	(10)

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